AN EXPERIMENTAL INVESTIGATION OF TEMAC PROGRAMED INSTRUCTIONAL MATERIALS AS THE INSTRUCTIONAL PROGRAM FOR FIRST YEAR ALGEBRA STUDENTS IN GRADES TEN, ELEVEN, AND TWELVE

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Jerry C. Gay
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by

Jerry C. Gay

Approved by Committee:

Raymond A. Hock
Chairman

B. C. Gillam

Earle L. Canfield
Dean of the School of Graduate Studies

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

The mathematics curriculum of high schools in the United States is today experiencing a revolution of thought, content, and presentation. In the area of presentation serious doubts are being raised about the value of the traditional teacher centered procedure of the blackboard-lecture method. One of the methods thought to have certain advantages over blackboard-lecture is the use of programed materials. It will be the purpose of this paper by means of experimental research to evaluate one set of programed materials, TEMAC, as the basic instructional program for students of first year algebra in grades ten, eleven, and twelve.[1] The experimental study was conducted at Herbert Hoover high school of Des Moines, Iowa, and lasted for a period of one full school year.

REASON FOR STUDY

The experimental research of this study was a result of the fact that during the 1967-68 school year the mathematics department of Herbert Hoover high school in Des

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[1] J. E. and O. G. Forbes, Modern Algebra, TEMAC Programmed Learning Materials (Chicago: Encyclopaedia Britannica Press, 1964).

Moines, Iowa, felt that its present method of blackboard-lecture was not fully meeting the educational needs of its first year algebra students. The senior high school students at Hoover, it was found, were not covering several of the topics covered by the junior high school ninth grade classes taking algebra I. In the succeeding course, geometry, students were taught on the basis that they had had the ninth grade algebra I curriculum. Thus the students from Hoover's algebra I classes were being placed in the difficult position of not having the expected full background for geometry.[1]

In the past this had not been a problem in the Des Moines Independent School District since algebra I taken at the senior high school level was considered a terminal course.[2] During 1967-68 Hoover was a new school and its students in algebra I did not seem to consider algebra I at the high school level as a terminal course. Registration for the 1968-69 school year showed that over two-thirds of Hoover's algebra I students planned to continue their mathe-

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[1]Opinions expressed by members of the mathematics departments of Hoover high school, Meredith junior high school and Franklin junior high school of Des Moines, Iowa, in personal interviews.

[2]Opinion expressed by Dr. Donald Wetter, Principal, Hoover high school and former system coordinator for mathematics, in a personal interview.

matics education with geometry.[1] At this point conversation within the Hoover mathematics department and with Mr. A. W. Goodwin, the Des Moines school district's mathematics coordinator, led to consideration of programed learning materials as useful in alleviating this problem. Programed materials with their stress on individual development might allow some of Hoover's algebra one students to obtain the full background for geometry, but at the same time not penalize the terminal students by forcing them to work at a rate beyond their ability.

RESEARCH HYPOTHESIS

It was the purpose of this project to test by experimental research the research hypothesis that TEMAC programed instructional materials provide an adequate method of instruction for first year algebra students in grades ten, eleven, and twelve. Test scores on a standardized algebra I posttest were used to measure how adequate the method of instruction was.

DEFINITIONS

In order to insure uniformity of thought between author and reader of this study it is essential that the

[1] Figures given by the guidance department of Hoover high school, Des Moines, Iowa, personal interview.

following terms and phrases be defined as they will be used in this study.

Blackboard-lecture. Blackboard-lecture in this study will mean instruction of the type in which the teacher presents a unit of study to the entire class by means of lecture and examples worked on the blackboard. Instruction of this type is basically teacher oriented and active student participation is limited to individual student questions and possible teacher-selected oral exercises. Due to the physical limitation of a single teacher, the group of individuals that make up the class is taught as a single unit. In the experimental study of this paper the control group was taught by the blackboard-lecture method.

Program and programed materials. A program defined by Robert Kalin in his article "Teaching Machines and Programed Learning" is:

> Subject matter arranged in a carefully planned series of sequential items and involving (a) controlled presentation of material (b) active response of learner (c) use of cues (prompts) to elicit correct responses in such a way as to enable individual learners to move ahead, independently and at their own pace, from familiar background to new and previously determined terminal behavior.[1]

A program as defined by Kalin is in line with the research

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[1]Robert Kalin, "Teaching Machines and Programed Learning," *The National Education Association Journal*, LI (November, 1961), 15.

of experimental psychologists such as B. F. Skinner. Skinner in the 1950's published several papers showing the value of small step by step learning, active participation by the learner, and reinforcement of correct responses.[1] Programed materials are a program produced in either book or mechanical form.

Programed instruction and programed learning. Programed instruction and programed learning are two terms used to describe instruction in which the student learns by the use of programed materials.

TEMAC. TEMAC is the commercial name given to the first year algebra I program by J. E. Forbes and O. G. Forbes. The program is published by Encyclopaedia Britannica Press, Inc., and is in book form. TEMAC materials consist of twenty-eight chapters in six units and five programed texbooks. Each book has a "Supplement" of practice problems and tests. The set also contains a teachers manual and two sets of twenty-eight tests, two equivalent tests for each chapter. The program is written in the form used by Skinner and his followers. William A. Deterline describes such a program as having many small steps. Students construct

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[1]William A. Deterline, An Introduction to Programed Instruction (Englewood Cliff, New Jersey: Prentice-Hall, Inc., 1962), pp. 11-13; and Benjamin Fine, Teaching Machines (New York: Sterling Publishing Co., 1962), pp. 45-48.

answers rather than select them from a list. There is a continual active response by the learner, and reinforcement of answers is immediate. Every effort is made to eliminate errors. The program provides for a wide range of student ability and allows each student to proceed at his own rate.[1] The experimental group in this study was taught by programed instruction using TEMAC.

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[1] William A. Deterline, _An Introduction to Programed Instruction_ (Englewood Cliff, New Jersey: Prentice-Hall, Inc., 1962), p. 20.

CHAPTER II

REVIEW OF RELATED LITERATURE

HISTORY

Programed instruction is not something particularly new or different. The question and answer technique is thousands of years old. Socrates in Athens twenty-four centuries ago was one of its advocates.[1] As far back as 1866 the United States government patented its first teaching machine. This machine, however, was not based on any scientific knowledge of learning and its program would not satisfy the present definition of a program.[2] In 1912 psychologist E. L. Thorndike in his book Education gave an outline for a programed learning device.[3] In the 1920's Sidney L. Pressey, a psychologist, developed and proved the workability of a mechanical teaching machine, the Pressey Drum Tutor. This device would be better described as a multiple choice testing device.[4] From the 1920's until the 1950's there was a lag in writings about programed instruc-

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[1] Benjamin Fine, Teaching Machines (New York: Sterling Publishing Co., 1962), p. 20.

[2] William A. Deterline, An Introduction to Programed Instruction (Englewood Cliff, New Jersey: Prentice-Hall Inc., 1962), p. 9.

[3] Fine, op. cit., p. 37. [4] Ibid.

tion. During the 1950's Harvard psychologist B. F. Skinner, in studies with pigeons, developed the theories of knowledge and learning that made possible the present definition of program and programed instruction.[1] Skinner's ideas and programed learning have not, however, been accepted without question. Thus the late fifties and the sixties have been marked by numerous studies on the advantages and disadvantages of programed learning.

CRITICAL REVIEW OF RELATED LITERATURE

Dr. Benjamin Fine in his discussion of programed learning as it applies to students of various levels in intelligence refers to three separate studies. The studies were (1) on bright students at Syosset, New York, (2) on average students at Roanoke, Virginia, and (3) a study by Professor Douglas Porter of Harvard University on below average students.

In Syosset, New York, TEMAC materials were tested on bright students. Students were divided into two groups, each group with a median I. Q. of 126. One group was taught by the use of TEMAC materials and the other by the blackboard-lecture method. At the end of the test period 38 per cent of the TEMAC students ranked above the ninetieth per-

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[1] *Ibid*., p. 39.

centile while 21 per cent of the blackboard-lecture class ranked above the ninetieth percentile. This was a statistically significant difference in favor of the TEMAC materials.[1]

In Roanoke, TEMAC programed algebra one materials were tested on average eighth grade students taking algebra. At the end of the test period 31 per cent of these students surpassed the national average for ninth grade students in the same subject.[2] In summary Fine made this statement:

> The average student will improve, but the teaching machine will not make him into a genius. What it does is remove the sense of inferiority . . . When you test an average student on a programed course, his scores may come quite close to those of a brighter student. The main difference is that he will be on frame 550 when the bright student is on frame 1000.[3]

In his studies with the below average student Porter found that programed materials produced the greatest gains in spelling for students with the lowest I. Q. Programed learning according to Porter gave these students encouragement they had never experienced before.[4]

The examples chosen by Fine for his endorsement of programed materials may be a little strong in their endorsement. Studies showing a statistical advantage for programed learning are in the minority. The overwhelming majority of all studies found programed materials neither statistically

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[1] _Ibid._, p. 83.

[2] _Ibid._, pp. 83-85.

[3] _Ibid._, pp. 84-85.

[4] _Ibid._, p. 85.

superior nor inferior to blackboard-lecture. Edward J. Zoll in the February, 1969, issue of <u>Mathematics Teacher</u> reported studies by Biddle, Kellems and Spagnoli that showed no significant difference in advantages or disadvantages of achievement when programed instruction was compared to blackboard-lecture.[1]

Fine's premise that programed instruction is applicable to students of all levels of ability has been endorsed by the results of a study by Glazer. Glazer in his study used 173 fourth grade students with a mean I.Q. of 116.45 ($s = 10.91$). Students with an I.Q. from 120 to 140 were placed in the high group and those with an I.Q. from 90 to 110 were placed in the low group. At the end of the test period he found that intelligence as measured by the Otis test had little or no relationship to the learning which occurred under programed instruction.[2]

Glazer in two additional studies found a definite statistically significant decrease in favorableness of attitude towards the use of programed materials as the study

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[1] Edward J. Zoll, "Research in Programed Instruction in Mathematics," <u>The Mathematics Teacher</u>, LXII, No. 2 (February, 1969), 103-104.

[2] Robert Glazer and others, <u>Studies of the Use of Programed Instruction in the Classroom</u>, a report prepared by the University of Pittsburg, Learning Research and Development Center through the Cooperative Research Program of the Office of Education, United States Department of Health, Education and Welfare, (May, 1966), pp. 65-69.

progressed. The effect of a decrease in favorableness as documented by Campbell, Bivens and Terry will be discussed following Glazer's study. Glazer found in a study of four seventh grade classes using seventh grade general science materials a score of favorability of 41.37 during the first week. By the end of the semester this score of favorability had dropped to 28.11.[1] The second Glazer study in the area of favorability found a significant decrease in the favorableness of attitudes towards the subject from the beginning to the end of the year with the use of programed algebra materials.[2] There is, however, reason to believe that the drop in favorableness is not totally related to programed instruction. Glazer in a study of sixty students in non-programed algebra classes found a significant decrease in favorableness of attitude during the course of a year. The loss for the non-programed student was less than for the programed students, but it was still at the .05 level.[3]

The effect of a decrease in favorableness has been documented by Campbell, Bivens and Terry. They found that with thirty-four ninth grade summer school algebra I students interest in the topic studied was a critical factor when students directed their own study in a linear self-

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[1] Ibid., pp. 101-103. [2] Ibid., p. 107.

[3] Ibid., p. 109.

directed program.[1]

Church, Brown and Twyford found programed instruction to be the most effective of thirteen classroom activities. Two classes of thirty-two students were taught by a single teacher. The thirteen algebra classroom activities that were used for a period of at least one hour during the school year were evaluated as to effectiveness determined by the ratings of learning by students. The Church study showed programed instruction not only to be the most effective activity, but 3.27 times as effective as questions by students, 2.30 times as effective as lecture, and 1.80 times as effective as writing on the overhead.[2]

In the study by Church, Brown and Twyford programed instruction was used on a very limited scale. During the entire year only two full units and a few partial units were programed. Consequently the length of time for programed learning was insufficient for determining a possible decrease in favorableness as described by Glazer.

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[1]Vincent N. Campbell, Lyle W. Bivens, and Donald F. Terry, Effects of Mathematical Ability, Pretraining, and Interest on Self-Direction in Programed Instruction, A Report prepared by the American Institute for Research, Palo Alto, California (Washington: Office of Education, United States Department of Health, Education and Welfare, October, 1963), p. 9.

[2]John G. Church, Robert M. Brown, and Loran C. Twyford, New Media for Improvement of Algebra Instruction, The State Education Department Bureau of Classroom Communications (New York: June, 1964), pp. 19-22.

Several studies, though unable to show a significant difference in test scores between programed instruction and blackboard-lecture, were able to show a valid benefit from the use of programed materials. McGarney in a six week summer period using TEMAC for an improvement course in algebra found a decrease in disciplinary problems as compared to regular teacher taught remedial classes.[1]

Kalin in a study investigating the teaching of mathematical equalities and inequalities to fifth and sixth graders of I.Q. over 115 found that the programed group had a 20 per cent savings of time when compared to the teacher taught group.[2] A savings of time was also found by Greatsinger. He found that an experimental group of sixth grade pupils taught division of fractions by means of programed instruction spent only 49.1 per cent of the time used by a blackboard-lecture control group.[3] Greatsinger also found that since teachers were free from preparing daily lesson plans and assignments that they could have more time avail-

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[1] Paul McGarvey, "Programed Instruction in Ninth-Grade Algebra," The Mathematics Teacher, LV (November, 1962), 577-578.

[2] Robert Kalin, "The Use of Programed Instruction in Teaching an Advanced Mathematics Topic," The Arithmetic Teacher, IX (March, 1962), 161-162.

[3] Calvin Greatsinger, "An Experimental Study of Programed Instruction in Division of Fractions," Audio Visual Communication Review, XVI, No. 1 (Spring, 1968), 89.

able to devote to the problems of individual students.[1]

SCOPE OF USAGE

Research and investigation of programed learning since Skinner has led to continual growth in the development and use of programed materials. By 1962 at least 630 programed courses had been developed.[2] In 1962 a survey was conducted for the United States Department of Health, Education and Welfare that mailed out questionnaires to 15,000 school superintendents. Two thousand of the superintendents completed and returned the questionnaires.[3] Sixty-one per cent of the reporting schools stated that they had used programed materials to teach mathematics during the school year 1961-62.[4] Of the schools reporting a use of programed materials in any subject area, 43 per cent were used in regular instruction and 25 per cent in an experimental situation.[5] The non-users expressed their interest in programed instruction in the following manner: (a) 30 per cent said they planned to use it for remedial work, (b) 20 per cent said

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[1] *Ibid.*

[2] Fine, *op. cit.*, p. 39.

[3] *The Use of Programed Instruction in U. S. Schools*, A report prepared by the Research Division, The Center for Programed Instruction, Inc., for the United States Department of Health, Education and Welfare, Office of Education (Washington: U. S. Government Printing Office, 1962), p. viii.

[4] *Ibid.*, p. 26.

[5] *Ibid.*, p. 11.

they planned to use it for regular instruction, (c) 35 per cent said they planned to use it for enrichment.[1] Within the state of Iowa, Porter, in a survey of programed instructional use during the 1962-63 school year, found that seventy-two Iowa schools indicated to the State of Iowa Department of Public Instruction that they were using some type of programed materials.[2]

SUMMARY

Educational research during the last twenty years has shown that programed materials can produce a positive educational change in the study of mathematics. There is still considerable doubt as to the extent of the advantages of programed materials. Many educational experts in the field of programed learning are convinced that programed materials provide a method significantly superior to blackboard-lecture. However, the majority of educators in the field of programed learning believe that programed materials produce an educational change in the student not significantly different from blackboard-lecture. Advantages that programed materials have are in the area of individualized rate of

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[1] Ibid., p. 12.

[2] Marie J. Porter, "Use of Programed Materials and/or Teaching Machines in Seventy-two Iowa Schools During 1962 and 1963" (unpublished Master's Thesis, Drake University, Des Moines, Iowa, 1964), p. 9.

development, economy of student time, and teacher availability for individualized instruction. Programed learning, however, is not without fault. Programed material that runs for a period of several weeks, such as TEMAC, may be affected by student disinterest. The longer a program runs the greater the problems of disinterest and boredom. With disinterest and boredom student failures increase. When advantages and disadvantages are considered together programed learning comes out as an educational tool that warrants test and evaluation in each individual circumstance.

CHAPTER III

RESEARCH METHODS

The methods of experimental research on teaching were used to test the research hypothesis that TEMAC programed instructional materials provide an adequate method of instruction for first year algebra students in grades ten, eleven, and twelve. The criteria for measuring adequacy were test scores on a standardized algebra I posttest.

PATTERN OF EXPERIMENTATION

The pattern of experimentation used for this study was based on a discourse by Campbell and Stanley concerning experimental and quasi-experimental designs for research on teaching.[1] The pattern of experimentation used involves an experimental group and a control group, both given a pretest and a posttest. The control group was taught algebra one by the blackboard-lecture method and the experimental group was taught algebra one by programed instruction using TEMAC.

CONTROL OF SELECTED FACTORS OF INTERNAL VALIDITY

The factors of internal validity are described by

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[1] Donald T. Campbell and Julian C. Stanley, "Experimental and Quasi-Experimental Designs for Research on Teaching," N. L. Gage, (ed.) Handbook of Research on Teaching (Chicago: Rand McNally and Company, 1963), pp. 171-246.

Campbell and Stanley as ". . . factors which by themselves could produce change which might be mistaken for the results of X."[1] History, maturation, testing, instrumentation, and mortality are five factors of internal validity listed by Campbell and Stanley.[2]

The general effects of history were controlled in this study by having both the control and the experimental group come from the student body of a single high school. Also, the two groups experienced their respective methods of instruction during the same school year. These same conditions were used to control maturation. Both the control and the experimental groups experienced their algebra one instruction for an identical period of one complete school year.

Testing and instrumentation were controlled by having both groups take the same standardized written pretest and posttest. Neither the administration nor the correction of either of these tests required or allowed for subjective tester evaluation of subject answers.

Subject mortality during the periods of instruction was controlled by including in the study only those subjects that took both the pretest and the posttest. Mortality included not only those subjects who dropped the course but

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[1] Ibid., p. 186.

[2] Ibid., pp. 183-185.

those subjects who changed groups and those subjects who entered a group after the pretest.

SAMPLE SELECTION AND DESCRIPTION

The subjects of this study were the members of two algebra I classes at Herbert Hoover high school of Des Moines, Iowa. The majority of the subjects registered in the spring of 1968 to take algebra I during the school year 1968-69. They were computer assigned to either section two or section three. Section two met period one from 8:31 A.M. until 9:26 A.M. five days a week. Section three met period six from 2:04 P.M. until 3:00 P.M. five days a week. Section one which also met period one was the only other algebra I class at Hoover during the year 1968-69. Section one did not take an active part in this study. The researcher of this study had no control over subject assignment to sections one, two, or three. The researcher, however, did arbitrarily pick section two as the experimental group and section three as the control group.

The control group, after allowing for mortality, was composed of twenty-eight subjects, twenty-six tenth graders and two eleventh graders. In the control group girls outnumbered boys by fifteen to thirteen. Examination of student files showed a ninth grade Lorge-Thorndike non-verbal

I.Q. range of 83 to 120.[1] On the quantitative test of the *Iowa Test of Educational Development* taken in the fall of 1968 the control group, according to national norms, had a range from the eleventh percentile to the seventy-third percentile.[2]

The experimental group, after allowing for mortality, was composed of twenty-seven subjects, twenty-four tenth graders, two eleventh graders and one twelfth grader. Again girls outnumbered boys, this time by fourteen to thirteen. Examination of student files showed for the experimental group a ninth grade *Lorge-Thorndike* non-verbal I.Q. range of 90 to 118.[3] On the *Iowa Test of Educational Development*, quantitative thinking test, taken in the fall of 1968 the range according to national norms was from the second percentile to the eighty-ninth percentile.[4]

PRETEST

During the first week of the 1968-69 school year both the control and the experimental groups were given the *Iowa Algebra Aptitude Test, Revised Edition* by H. A. Greene and

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[1]Information obtained from student files maintained by the guidance department of Herbert Hoover high school, Des Moines, Iowa.

[2]*Ibid.*

[3]*Ibid.*

[4]*Ibid.*

and A. H. Piper.[1] David Segel, Specialist in Tests and Measurements, U. S. Office of Education, Washington, D. C., described the _Iowa Algebra Aptitude Test, Revised Edition_ as:

> One of the best tests for prognosis of success in algebra. The relationship between the scores on this test and success in algebra is substantially higher than that existing between success and any intelligence test using comparable test time.[2]

The test consists of 105 questions divided into four parts and takes thirty-five minutes. The revised edition was copyrighted in 1942. In general, the test covers arithmetic problems, abstract computation, numerical series, and a test for the understanding of the relationship of parts of an equation.[3] The copyright date of 1942 in all probability outdates and invalidates all norms for 1969 students. However, in this study only raw scores were computed and compared. Pretest scores and an analysis of their results are presented in Chapter IV and the Appendix.

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[1] H. A. Greene and A. H. Piper, _Iowa Algebra Aptitude Test, Revised Edition_ (Iowa City: Bureau of Educational Research and Service, Extension Division, 1942). See Appendix for a copy of the pretest.

[2] Oscar Krisen Buros (ed.), _The Third Mental Measurements Yearbook_ (New Brunswick: Rutgers University Press, 1949), p. 418.

[3] _Ibid_.

ADMINISTRATION OF THE TEACHING-LEARNING EXPERIENCES

At the completion of the pretest the experimental group, section two, was taught algebra I by programed instruction using TEMAC materials. The first two days were spent explaining the concept, advantages, and principles of programed instruction. Each student was given a short mimeographed description of programed learning and asked to have his parents read the description.[1] Each student and his parents were invited to contact the instructor of the programed course if there were any questions. This procedure was followed up and repeated for the parents at the all school open house approximately one month later. The third day after the pretest the instructor and the entire experimental group went through the first section of chapter one, unit one of TEMAC. This completed group instruction and from this point on all members of the control group worked independently.

Working independently each student proceeded through the TEMAC materials at his own rate and with a minimum of teacher assistance. At the completion of each chapter the student took one of the TEMAC'S two equivalent 100 point tests over the chapter. The test was corrected and evalu-

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[1]See the Appendix for a copy of the explanation.

ated by the instructor. The instructor then returned the test to the student and individually with that student discussed problems missed and suggested remedial exercises. At the completion of the remedial exercises the student had the option of taking the second equivalent test over the chapter. The student's grade for a chapter was determined by his highest test score.

School district grading policy required that each student be graded four times a year. District policy also required that the parents of students in danger of failing be notified prior to each grading period. In order to comply with these policies, to reduce the problem of students not working at or near their capacity, and to be consistent with grade notification within the control group, grade standards were posted every two or three weeks.[1] Also, any student not completing at least one chapter in a two week period was individually contacted and the reason for lack of advancement was discussed.

Programed instruction was terminated at the end of the 1968-69 school year by the administration of the post-test.

While the experimental group was going through the experience of programed learning, the control group was

[1] See the Appendix for the grade standards for first, second, third, and fourth nine week periods.

being taught algebra one by the blackboard-lecture method. The textbook used was Modern Algebra Structure and Method by Dolciani, Berman and Freilich.[1] All procedures of testing and grading were at the discretion of the instructor. Since members of the control group were made aware of their grade by a test or quiz approximately every week, no system of posting standards was used. The methods of blackboard-lecture were terminated at the end of the 1968-69 school year by the administration of the posttest.

POSTTEST

At the completion of programed instruction and the use of the blackboard-lecture method both the control and the experimental groups were given as a posttest the Lankton First-Year Algebra Test, Revised Edition.[2] The test consists of fifty multiple choice questions that are to be answered in a forty minute period. The test was designed to blend traditional algebra concepts with the new content of modern algebra instruction as prepared by the School Mathe-

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[1]Mary P. Dolciani, Simon L. Berman, and Julius Freilich, Modern Algebra Structure and Method (Boston: Houghton Mifflin and Company, 1962).

[2]Robert S. Lankton, Lankton First-Year Algebra Test, Revised Edition (New York: Harcourt, Brace and World, Inc., 1965). See the Appendix for a copy of the posttest.

matics Study Group and others.[1] Item-tryout and standardization were carried out during the spring of 1964. Experimental forms of 110 items were administered to 5,040 first-year algebra students in twenty-eight public high schools and sixteen states.[2]

STATISTICAL METHODS

The statistical methods of this study were based on <u>Statistical Concepts</u> by Celeste McCollough and Loche Van Atta.[3] A <u>t</u>-test for testing the difference between means of uncorrelated samples was applied to the pretest results.[4] The <u>t</u>-test was used to determine if "these samples were just two slightly varying samples drawn from the same population."[5] The effect of teaching algebra I by use of TEMAC versus the blackboard-lecture method was tested by applying the same type of <u>t</u>-test to the posttest results. The <u>t</u>-test for the posttest was used to determine if the samples were still two not significantly different samples drawn from the same population.

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[1] Robert S. Lankton, <u>Lankton First-Year Algebra Test, Revised Edition Manual</u> (New York: Harcourt, Brace and World, Inc., 1965), p. 4.

[2] <u>Ibid</u>.

[3] Celeste McCollough and Loche Van Atta, <u>Statistical Concepts</u> (New York: McGraw-Hill Book Co., Inc., 1963).

[4] <u>Ibid</u>., pp. 238-242. [5] <u>Ibid</u>., p. 238.

SUMMARY

During the 1968-69 school year two classes of algebra I students from Hoover high school in Des Moines, Iowa, were used to test the value of TEMAC materials for algebra I. Both groups were administered the <u>Iowa Algebra Aptitude Test, Revised Edition</u> at a pretest. At the completion of the pretest a set of twenty-seven students, the experimental group, was taught algebra I by the use of TEMAC materials. The other class, a control group of twenty-eight members was taught algebra I by the blackboard-lecture method. Both groups were given the <u>Lankton First-Year Algebra Test, Revised Edition</u> as a posttest. A t-test for testing the difference between means of uncorrelated samples was used on the results of the pretest and the posttest to determine if the groups before and after instruction were two not significantly different samples drawn from the same population.

CHAPTER IV

ANALYSIS OF RESULTS OF EXPERIMENTATION

The findings of this study indicated that the experimental group taught by TEMAC materials experienced no significant learning difference in first year algebra when compared to the control group taught by the blackboard-lecture method.

The results of the *t*-test for the difference between means as shown by the pretest is presented in Table I. The experimental group was found to have a mean of 51.96 ($s = 10.07$) on the pretest. The control group mean was found to be 2.97 points higher at 54.93 ($s = 7.73$). These scores resulted in an insignificant *t*-score of 1.207. Thus, prior to algebra one instruction the experimental and the control groups were two not significantly different groups drawn from the same population.

The results of the *t*-test used to determine the difference between means as shown by the posttest is presented in Table II. Again the experimental group had a slightly lower mean than the control group. The experimental group had a posttest mean of 23.96 and the control group had a posttest mean of 25.39. The difference however, was not found to be significant. The *t*-score was 0.99. It can be stated that after algebra I instruction the experimental and

TABLE I

RESULTS OF SIGNIFICANCE FOR THE PRETEST

Group	Mean	Standard Deviation	d.f.
Experimental	51.96*	10.07	26
Control	54.93*	7.73	27
Difference in means		2.97	
Combined degrees of freedom		53	
"t"#		1.207	

TABLE II

RESULTS OF SIGNIFICANCE FOR THE POSTTEST

Group	Mean	Standard Deviation	d.f.
Experimental	23.96*	5.66	26
Control	25.39*	4.81	27
Difference in means		1.43	
Combined degrees of freedom		53	
"t"#		.99	

*For a more complete breakdown of subject scores see Table VI in the Appendix.

#Not significant according to Table III of R. A. Fisher and F. Yates, <u>Statistical Tables for Biological Agriculture and Medical Research</u> (Edinburgh: Oliver and Boyd, Ltd., 1963), p. 46.

the control groups were two not significantly different groups drawn from the same population.

Though the experimental and control groups showed no significant difference, individual student comparisons showed some possible differences. All members of the control group taught by the blackboard-lecture method covered exactly the same topics. The control group in completing chapters one through nine plus sections 10-1, 10-2, and 10-3 in the test Modern Algebra, Structure and Method by Dolciani, Berman, and Freilich was introduced to the following topics: (a) the number line, (b) equality and inequality, (c) sets and subsets, (d) variables and open sentences, (e) properties of real numbers, (f) solving equations and inequalities, (g) polynomials, (h) polynomial products and factoring, (i) algebraic fractions, (j) graphs of open sentences in two variables, (k) graphic solution of two equations in two variables.[1] As in teaching to any heterogeneous group there was a wide range in the success which individual students experienced. Testing showed that some students understood every topic, some students understood most of the topics, and some students understood very few topics. But no member of the control group covered any topic other than

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[1]Mary P. Dolciani, Simon L. Berman, and Julius Freilich, Modern Algebra, Structure and Method, Teachers Manual (Boston: Houghton Mifflin Company, 1962), pp. 3-33.

those covered by the entire class. Thus, learning differences within the control group were limited to a depth and understanding of common topics. In the experimental group there was, however, a range in the topics covered. A formal breakdown of the topics a student could cover is presented in Table III. The table shows that each chapter of the TEMAC materials does not necessarily mean a new topic but the greater the number of chapters covered the greater the number of topics covered. Table IV shows the distribution of chapters covered by the experimental group. Tables III and IV together show that factoring is an example of a topic that not all students using TEMAC were able to cover. According to Table III factoring was introduced for the first time in chapter twenty of TEMAC. As Table IV shows only fourteen of the twenty-seven students in TEMAC covered chapter twenty. Thus, programed instruction using TEMAC allowed for a range in the topics covered by individual students. Since the experimental group was heterogeneously grouped it, like the control group, had a range of student success on individual topics. Programed instruction using TEMAC allowed for both a difference in depth on common topics and for a range in the number of topics covered.

TABLE III

ORDER OF TOPIC PRESENTATION FOR TEMAC*

Topics	Chapters Covering Topics
Number Systems	1-6, 26
Properties of Operations on Numbers	1-9, 14, 15, 19-22, 26
Fractions and Rational Expressions	4, 5, 10, 20, 23-25
Simplification of Expressions	7-10, 14, 15, 18-20, 24-26
Exponents and Radicals	18-20, 23, 24, 26, 27
Solution Sets of Open Sentences	6-10, 12-14, 17, 21, 24, 27, 28
Graphs	6, 12-15, 17, 25, Appendix
Arithmetic of Expressions Containing Variables	7-10, 14, 15, 19, 22-26
Language of Sets	6, 12, 13, 15, 17, 21, 22, 24, 27
Verbal Problems	11, 16, 21, 22, 25
Inequations	5, 12, 17
Absolute Value	1, 5, 9, 12, 27
Ratio, Proportion & Variation	5, 25
Functions	Appendix
Systems of Open Sentences	15, 17, 25
Factoring	20, 28

*J. E. and O. G. Forbes, Modern Algebra, A First Course, TEMAC, Teachers Manual (Chicago: Encyclopaedia Britannica Press, 1964), p. 6.

TABLE IV

TEMAC CHAPTERS COVERED BY THE EXPERIMENTAL GROUP

Chapter Number	Number of Subjects Finishing the Chapter
14	27
15	26
16	26
17	26
18	24
19	21
20	14
21	6
22	4
23	4
24	3
25	3
26	1
27	0
28	0

The average number of chapters covered was 19.85 chapters.

SUMMARY

Evaluation of pretests and posttests by use of *t*-tests shows that there is no significant difference between a group taught by the blackboard-lecture method and a group taught by programed instruction. Possible differences noted were on an individual basis. The blackboard-lecture method allowed only for a depth of learning on common topics while programed instruction allowed for both a depth on common topics and for a range in the number of topics covered.

CHAPTER V

RECOMMENDATIONS AND CONCLUSIONS

Analysis of the statistical data of this experimental study indicated that programed materials did not produce a significant difference between the control and the experimental groups of tenth, eleventh, and twelfth grade students taught algebra I. Based on t-test evaluations of pretest and posttest scores it was found that the group taught by means of TEMAC and the group taught by blackboard-lecture were just two slightly varying samples drawn from the same population. However, examination of individual student progress indicated that programed instruction allowed for a greater range of topics covered by individual students.

Based on the research and the results of this study it is recommended that large scale studies, in which programed instruction is used in the teaching of algebra I to high school students, be undertaken. Almost all studies on the use of programed materials for algebra I have been on junior high students of grades eight or nine. Algebra I students of grades ten, eleven, and twelve have different educational problems than students of grades eight or nine. These students, for some reason, chose in ninth grade to deviate from the standard procedure and not take algebra I until a later date. There must be an explanation for this deviation and it would seem logical that it would have some effect on how they learn algebra I.

Factors about the use of programed materials for grades ten, eleven, and twelve that would be worthy of large scale studies would be as follows:

1. Research should be undertaken that measures the effect of programed instruction on the individual. Studies to date have put their stress on the group rather than on the individual. Thus, very little is known about the effect of programed learning on the individual. Studies putting stress on the individual could answer questions such as (a) What are the effects of individual student ability, motivation, and personality on the learning of algebra one by programed instruction? (b) What is the effect of programed instruction on the whole child? That is, not only how it affects mental ability, but how it affects characteristics such as personality and social development. (c) Does programed instruction actually allow every student to learn at his own rate?
2. Studies should be conducted on how teacher interest affects student learning by means of programed instruction. There are indications that teacher interest can be as important as student interest.

3. A study should be conducted to measure the effect of learning under forced pacing versus a freely chosen pace. Forced pacing is the intentional or unintentional result when instructors set completion standards and dates. Forced pacing is a condition in almost every study conducted in an actual classroom condition. Parents and school boards require grades and course completion by a set date. Thus, no student really is allowed to work freely at his own rate.

4. A financial evaluation of programed instruction should be conducted. In this era of ever rising education costs educators have an obligation to the tax payers to provide an efficient educational system. A financial evaluation could include the cost of producing a program and ideal class size.

5. Short term and long term follow up studies should be undertaken. A learning situation is of value only if the student is able to retain the basic concepts after the learning experience. Very few algebra I students will become mathematicians but every algebra I student will have a need for the basic number concepts of algebra. If programed instruction is a worthwhile method of instruction it will hold up under long term evaluation.

The results of this study on programed instruction, even without completion of the recommended research, show that programed instruction is a seemingly valid method of teaching algebra I to students of grades ten, eleven, and twelve. There was no significant difference in learning experience by the group taught by the blackboard-lecture method and the group taught by programed instruction. The group taught by programed instruction using TEMAC, however, did experience a range in topics covered by individual students. This range in topics covered was in contrast to the experience of the group taught by the blackboard-lecture method. Every student in the blackboard-lecture group covered exactly the same topics. At worst, the study would indicate that statistically programed instruction is equivalent to the blackboard-lecture method.

The range in topics covered by the experimental group using TEMAC could be considered as an advantage for programed instruction. The study showed that this range was obtained without creating a significant difference between the two total groups. A worth-while goal in education is to educate every student to his fullest capacity. The individual, however, cannot be educated to his fullest capacity when he is forced to conform to the achievement of the group. At the same time the learning accomplishments of the group cannot be sacrificed merely to allow a few individuals to learn to their capacity. This study has indicated that programed learning can allow individual students to learn beyond the range of the group and that this learning need not be at the expense of the group.

The author of this study, as instructor of both the control and the experimental groups, observed several conditions that indicated possible additional advantages for programed instruction. (1) Since daily lesson plans are not needed there is a definite reduction in the amount of out of classroom work required from the teacher. This saved time can be used to prepare enrichment materials for algebra one or to improve preparation for other classes. (2) The teacher, since he is freed from large group instruction, can spend his time on individual and small group instruction. Many teachers and students find this type of instruction more worth-while and rewarding than large group instruction. (3) The individualized instruction just mentioned in many cases allows for a closer teacher and student relationship. This closer relationship can allow the teacher to work closer with the guidance department in the solving of student problems. (4) The fact that all students are not studying the same material means that neighboring students have very little reason to converse during class time. Thus, many of the minor discipline problems resulting from student to student conversation are eliminated. (5) Since programs are written to provide a minimum number of chances for failure both the student and the teacher are less often plagued by a feeling of failure. Experience has shown that in a blackboard-lecture high school algebra I class the feeling of failure can be very prevalent in both the students and the teacher. (6) Since each student works independently the effect of student absences is minimized. The program taught student never misses a lecture, film, or presentation. Thus, he never has the problem of making up a missed learning activity.

John D. McNeil in his book, Curriculum Administration, very adequately describes the philosophy one should have in his search for a perfect program of instruction. McNeil says:

> It should be remembered that one will never find a perfect program. The goodness of a program depends upon the objectives held, the population of learners, and the conditions in which it will be offered. It looks as if programed material will be subject to higher standards of appraisal than any other instructional media. If textbooks and teachers themselves had to pass the proposed standards, schools would be paragons of virtue or closed for lack of qualified instruction - most likely the latter.[1]

Programed instruction is a revolutionary method of instruction. It is a method in instruction that progressive educators must evaluate and use when the circumstances warrant its usage.

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[1] John D. McNeil, Curriculum Administration (New York: The MacMillan Company, 1965), p. 19.

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APPENDIX

APPENDIX A

COPY OF THE PRETEST

45

IOWA ALGEBRA APTITUDE TEST

Revised edition

By

H. A. Greene and A. H. Piper

Name .... last .... first .... Age .... years .... mos.

Name of School .... Grade ....

Name of City .... State ....

Have you ever taken first year algebra before? Yes .... **No** ....

TEST RECORD

	Part 1	Part 2	Part 3	Part 4	Total
Perfect Scores	30	25	40	10	105
Pupil's Scores					
Percentile Scores					

Part 1. ARITHMETIC

Time allowance—12 minutes

Directions: Work each arithmetic example as directed. Do your work on this sheet or on other paper. Compare your answers with those given in the numbered answer spaces at the right. For each example, three possible answers are given, only one of which is right. Place a cross (×) in the circle directly over the answer that agrees with yours. If no answer agrees with yours, place the × in the circle over "Not Given." You will receive no credit for a correct answer unless it is marked in the correct answer space. The samples at the right are answered correctly.

Samples — **Answers**

A. Add: 286
475
761

A. ○ 751 ⊗ 761 ○ 771 ○ Not Given

B. $\frac{1}{2} + 2\frac{1}{2} = 3$

B. ○ 2 ○ 4 ○ 5 ⊗ Not Given

ANSWERS

1. Add
7
9
8
4
3
5
6

Check your answer here →

1. ○ 40 ○ 41 ○ 42 ○ Not Given

2. Subtract
978
249

2. ○ 729 ○ 739 ○ 1227 ○ Not Given

3. Divide: 8/ 424

3. ○ 52 ○ 54 ○ 56 ○ Not Given

Turn to page 2 and go right on working.

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Published by Bureau of Educational Research and Service, Extension Division, University of Iowa, Iowa City

Part 1. ARITHMETIC—(Continued)

ANSWERS

4. Multiply
934
29
Check your answer here →

4. ○ 27,086 ○ 26,996 ○ 27,096 ○ Not Given

5. Add
75
98
468
976

5. ○ 1597 ○ 1607 ○ 1617 ○ Not Given

6. Write the fraction $3/10$ as a per cent. ________

6. ○ .3 ○ 3% ○ 30% ○ Not Given

7. What is the product of seventy-two and zero? ________

7. ○ 0 ○ 1 ○ 72 ○ Not Given

8. Subtract
15434
7970

8. ○ 8564 ○ 7464 ○ 7460 ○ Not Given

9. Divide: $9\overline{)34704}$

9. ○ 3805 ○ 3850 ○ 3856 ○ Not Given

10. Add
743
594
764
435

10. ○ 2336 ○ 2526 ○ 2535 ○ Not Given

11. Solve
$4/7 \div 4/5 =$ ________

11. ○ $1\,2/5$ ○ $5/7$ ○ $16/35$ ○ Not Given

12. Write the decimal .34 as a per cent. ________

12. ○ .34% ○ 3.4% ○ 34% ○ Not Given

13. Change this per cent to a fraction: 120% ________

13. ○ $1\,1/3$ ○ $1\,1/5$ ○ $1\,1/4$ ○ Not Given

14. Five Hundred Twelve Dollars less \$104.76 = ________

14. ○ 407.24 ○ 408.34 ○ 616.76 ○ Not Given

15. What must be added to 537 to make 1195? ________

15. ○ 537 ○ 668 ○ 1732 ○ Not Given

16. Multiply
427
306

16. ○ 15,372 ○ 130,562 ○ 130,662 ○ Not Given

17. What is 15% of 80? ________

17. ○ 8 ○ 12 ○ 15 ○ Not Given

Turn to page 3 and go right on working.

Part 1. ARITHMETIC—(Continued)

Problem		ANSWERS			
18. Subtract 15 − $9\frac{3}{5}$	18.	$6\frac{3}{5}$	$5\frac{3}{5}$	$5\frac{2}{5}$	Not Given
19. Divide and point off: 34/205.02	19.	6.03	6.3	60.3	Not Given
20. Solve $\frac{3}{2} \times \frac{5}{12} =$	20.	$3\frac{3}{5}$	$1\frac{3}{5}$	$\frac{5}{8}$	Not Given
21. Add $3\frac{1}{12}$, 9, $5\frac{5}{8}$	21.	$18\frac{7}{24}$	$17\frac{17}{24}$	$17\frac{3}{4}$	Not Given
22. What is 120% of 15? ______	22.	$1\frac{1}{5}$	18	60	Not Given
23. Divide and point off: .24/ .51432	23.	21.43	2.143	.2143	Not Given
24. Solve: $8\frac{1}{3} - 3\frac{7}{9} =$ ______	24.	$5\frac{4}{9}$	$4\frac{5}{9}$	$3\frac{8}{9}$	Not Given
25. What per cent of 20 is 4? ______	25.	5	8	25	Not Given
26. Solve: $\frac{2}{5} \div 1.2 =$ ______	26.	3	$2\frac{1}{12}$	$\frac{1}{3}$	Not Given
27. Solve: $\frac{3}{4} \times 15 =$ ______	27.	$11\frac{1}{4}$	20	$\frac{1}{20}$	Not Given
28. Multiply and point off: 20.73 × 40.3	28.	835.419	8354.19	89.049	Not Given
29. Copy and add .003 + 4.2 + 7.65 + .17	29.	8.27	12.023	12.23	Not Given
30. Goods marked at 125% of cost sell at \$7.50. What is the cost?	30.	6.00	5.83	5.62	Not Given

Copy Example 29 here:

Score on Part 1 = Number right = ____________

End of Part 1.

Do not turn to the next page until told to do so.

Part 2. ABSTRACT COMPUTATION

Time allowance—8 minutes

Directions: The answers to these problems are obtained by adding, subtracting, multiplying, dividing, or by making combinations of these processes. Study each problem carefully and make up your mind what the answer is to the question asked in each problem. Find this answer in the answers at the right of the question and make a cross (X) in the circle above the correct answer. If you find no answer that agrees with yours place the X in the circle over "Not Given." The sample is answered correctly.

			Answers			
Sample. A.	How many pencils would I have if I bought *k* pencils and some one gave me *m* pencils more?	**A.**	○ $k - m$	⊗ $k + m$	○ $k \div m$	○ Not Given

The correct answer is found by adding the *k* and the *m*. The answer is $k + m$, so the space over this response is marked with an X.

			ANSWERS			
1.	Monday I read *a* pages of a book, Tuesday I read *b* pages, Wednesday I read *c* pages. How many pages did I read altogether?	**1.**	○ abc	○ $a+b+c$	○ $3abc$	○ Not Given
2.	Ray wants to buy a gun which costs *x* dollars. He has *y* dollars, but that is not enough. How many more dollars does he need?	**2.**	○ $x+y$	○ xy	○ $x-y$	○ Not Given
3.	What is the volume of a room which is *r* feet wide, *s* feet long and *t* feet high?	**3.**	○ rst	○ $r+s+t$	○ $r+st$	○ Not Given
4.	John and James have *x* marbles between them, and each has as many as the other. How many has each?	**4.**	○ $2x$	○ $\frac{2}{x}$	○ $\frac{x}{2}$	○ Not Given
5.	If one load of coal costs *c* dollars, what will be the cost of *b* loads of such coal?	**5.**	○ $b-c$	○ $b+c$	○ $\frac{b}{c}$	○ Not Given
6.	A man 45 years old has a son who is *y* years younger. Indicate the age of the son.	**6.**	○ $y-45$	○ $45-y$	○ $45y$	○ Not Given
7.	Indicate the number of days in *r* weeks.	**7.**	○ $7r$	○ $\frac{r}{7}$	○ $r+7$	○ Not Given
8.	How much money in Joe's bank account when *y* dollars are deposited and *x* dollars withdrawn if the previous balance was *k* dollars?	**8.**	○ $y-xk$	○ $k+y-x$	○ $y-k+x$	○ Not Given
9.	If a certain number be represented by *x* and we give *x* a value of 5, what would be the value of $x + 2$?	**9.**	○ 10	○ $5x+2$	○ 7	○ Not Given
10.	The interest on *s* dollars for one year amounts to *d* dollars. How much will be the simple interest at the end of *y* years?	**10.**	○ sd	○ dy	○ ys	○ Not Given
11.	Indicate the number of pennies in *m* dimes and 2 pennies.	**11.**	○ 12	○ $m+2$	○ $10m$	○ Not Given
12.	One day a boy caught *f* fish, then gave away *a* of them. The next day he caught *b* more, but sold half of them. How many fish had he left?	**12.**	○ $fa-b$	○ fab	○ $f-a+\frac{1}{2}b$	○ Not Given

Turn to page 5 and go right on working.

Part 2. ABSTRACT COMPUTATION—(Continued)

		ANSWERS			
13.	If the product of two numbers is 24, and one of them is *m*, indicate the other number. .... 13.	○ 24÷m	○ 24m	○ 24—m	○ Not Given
14.	If the quotient of two numbers is *y* and the divisor is *m*, represent the dividend. .... 14.	○ y÷m	○ my	○ m÷y	○ Not Given
15.	How many hours will it take a person to go *m* miles, if he goes *r* miles in one hour? .... 15.	○ rm	○ r÷m	○ m÷r	○ Not Given
16.	Represent the integer next larger than the one represented by *m*. .. 16.	○ m	○ m+1	○ 1—m	○ Not Given
17.	A man has *y* dollars. Indicate how much he has left after spending one-third of his money. .... 17.	○ y+⅔	○ ⅓y	○ y	○ Not Given
18.	I bought *m* 2-cent stamps, and three times as many 1-cent stamps. How many stamps did I buy altogether? .... 18.	○ 3m	○ m+3	○ 4m	○ Not Given
19.	If *y* represents an even number, represent the next larger even number. .... 19.	○ y+2	○ y+1	○ 2y+1	○ Not Given
20.	A book, a pencil, and a tablet together cost *y* cents. If the pencil cost *m* cents, and the tablet twice as much as the pencil, what did the book cost? .... 20.	○ y—3m	○ 2m—y	○ 3m	○ Not Given
21.	One roll of telephone wire will reach *f* feet. How many rolls of such wire are needed to reach *t* feet? .... 21.	○ t—f	○ t÷f	○ tf	○ Not Given
22.	Three boys decide to run a refreshment stand. The equipment costs *r* dollars. The father of one of the boys gave them $20.00. Indicate how much each boy will have to pay, if the remaining expense be divided evenly among them. .... 22.	○ r+20÷3	○ 20r÷3	○ $\frac{r-20}{3}$	○ Not Given
23.	A horse runs *m* miles in *c* minutes. How many miles will it run in one-fifth of a minute? .... 23.	○ m÷5c	○ m÷⅕c	○ 5mc	○ Not Given
24.	A man has 4 bins each capable of holding *a* bushels of grain. These bins are empty. He buys *b* loads of grain, each load containing *c* bushels of grain, which his present bins will not hold. Indicate the capacity of the new bin he will need to build in order to have sufficient room for the grain. .... 24.	○ bc—4a	○ 4a—bc	○ 4a+bc	○ Not Given
25.	A newspaper charged $8.00 for the first insertion of an advertisement, and $4.00 for each following insertion. Express the cost of *n* insertions. .... 25.	○ 4(n—2)	○ 4(n—1)	○ 4(n+1)	○ Not Given

Score on Part 2 = Number right = ____________

End of Part 2.

Do not turn to next page until told to do so.

Part 3. NUMERICAL SERIES

Time allowance—12 minutes

Directions: Each of the following number series is made up according to some rule. Addition, subtraction, multiplication, and division, and various combinations of these processes are used in forming the different series. Discover the rule for each example, decide what the next term would be, and write it on the blank line following the series. Then place a cross (X) in the circle directly over the answer that agrees with yours. If no answer agrees with yours place the X in the circle over "Not Given." You will receive no credit for a correct answer unless it is marked in the correct answer space. The sample is answered correctly.

									Answers			
Sample:	1	2	3	4	5	6	7	*8*	○ 7	⊗ 8	○ 9	○ Not Given

ANSWERS

1.	2	4	6	8	10	______		1.	○ 11	○ 12	○ 13	○ Not Given
2.	9	8	7	6	5	______		2.	○ 5	○ 3	○ 2	○ Not Given
3.	1	1	5	5	9	9	______	3.	○ 11	○ 12	○ 13	○ Not Given
4.	2	4	8	16	32	______		4.	○ 48	○ 64	○ 96	○ Not Given
5.	5	8	11	14	17	______		5.	○ 20	○ 21	○ 23	○ Not Given
6.	12.9	11.8	10.7	9.6	8.5	______		6.	○ 8.3	○ 7.4	○ 6.5	○ Not Given
7.	1	4	7	10	13	______		7.	○ 19	○ 17	○ 15	○ Not Given
8.	r^6	6r	r^5	5r	r^4	______		8.	○ r^5	○ $4r^5$	○ 4r	○ Not Given
9.	12	0	10	0	8	0	______	9.	○ 6	○ 4	○ 0	○ Not Given
10.	1	3	6	10	15	______		10.	○ 20	○ 21	○ 22	○ Not Given
11.	42	37	32	27	______			11.	○ 22	○ 23	○ 24	○ Not Given
12.	128	64	32	16	8	______		12.	○ 0	○ 6	○ 4	○ Not Given
13.	4	5	7	8	10	______		13.	○ 12	○ 10	○ 11	○ Not Given
14.	9/9	8/10	7/11	6/12	______			14.	○ 5/12	○ 4/15	○ 5/13	○ Not Given
15.	3	2	4	3	5	4	______	15.	○ 6	○ 5	○ 4	○ Not Given
16.	2	5	9	14	20	______		16.	○ 27	○ 26	○ 25	○ Not Given
17.	17	17	13	9	9	______		17.	○ 4	○ 5	○ 6	○ Not Given

Turn to page 7 and go right on working.

Part 3.—NUMERICAL SERIES—(Continued)

Item	Series		ANSWERS			
18.	2 4 6 7 9 11 ______	18.	14	12	11	Not Given
19.	ab 4589 2ab 458 3ab ______	19.	45	58	4ab	Not Given
20.	24 23 22 20 19 18 ______	20.	14	15	16	Not Given
21.	$\frac{a+4}{2a}$ $\frac{a+10}{5a}$ $\frac{a+16}{8a}$ ______	21.	$\frac{a+18}{9a}$	$\frac{a+20}{10a}$	$\frac{a+22}{11a}$	Not Given
22.	243 81 27 9 ______	22.	6	4	2	Not Given
23.	2 6 10 11 15 19 ______	23.	20	21	24	Not Given
24.	25 28 29 33 36 ______	24.	37	41	43	Not Given
25.	56342 xy^2 5634 x^2y^3 563 x^3y^4 ______	25.	x^4y^5	6	3	Not Given
26.	$\frac{y^{48}}{a+b+c+d}$ $\frac{y^{24}}{b+c+d}$ $\frac{y^{12}}{c+d}$ ______	26.	$\frac{y^6}{d}$	$\frac{y^3}{d}$	y	Not Given
27.	0 ⅗ 1⅕ 1⅘ 2⅖ ______	27.	2½	2⅘	3	Not Given
28.	4 5 10 11 22 23 ______	28.	24	46	47	Not Given
29.	2 4 8 14 22 ______	29.	44	34	32	Not Given
30.	$4y^8$ $5y^7$ $4y^6$ $7y^5$ $4y^4$ ______	30.	$4y^2$	$9y^3$	$11y^2$	Not Given
31.	1 3 7 15 ______	31.	31	30	29	Not Given
32.	3 8 13 18 23 ______	32.	31	29	27	Not Given
33.	48.08 24.04 12.02 ______	33.	6.2	6.1	6.01	Not Given
34.	1 3 7 8 11 18 26 ______	34.	33	37	39	Not Given
35.	5/32 5/16 ⅝ 1¼ 2½ ______	35.	3	3½	5	Not Given
36.	1 1 2 6 24 ______	36.	72	120	144	Not Given
37.	$2y^3-10$ $6y^8-16$ $10y^{13}-22$ ______	37.	$14y^{18}-28$	$15y^{17}-26$	$16y^{16}-24$	Not Given
38.	1/15 ⅕ ⅓ ______	38.	⅖	4/15	7/15	Not Given
39.	1 2 4 12 36 ______	39.	72	108	144	Not Given
40.	5/108 5/36 5/12 ⅘ 3¾ ______	40.	9¾	11¼	12	Not Given

Score on Part 3 = Number right = ______

End of Part 3. Do not turn to next page until told to do so.

Part 4. DEPENDENCE AND VARIATION

Time allowance—3 minutes

Directions: Each of the following exercises can be answered by one of the four numbered phrases given below each question. Study the example and the question based upon the example. Decide which one of the numbered phrases below the question is the correct answer. Note the number of this phrase. Find this number among the answer spaces at the right of the question and make a cross(X) in the correct circle. The sample is answered correctly.

Sample: $X - 7 = 10$ If the 7 were made larger, what change would need to be made in the value of X so that the answer 10 would still be correct?

(1) **remain the same** (2) **become larger** (3) **become smaller** (4) **cannot tell.** .... (1) ○ (2) ⊗ (3) ○ (4) ○

---

(1) (2) (3) (4)

1. $X = y$ If y were made larger, what change would be made in the value of X?
(1) **remain the same** (2) **become larger** (3) **become smaller** (4) **cannot tell** .... 1. ○ ○ ○ ○

2. $X = y + m$ If y were made smaller, what change would be made in the value of X?
(1) **remain the same** (2) **become larger** (3) **become smaller** (4) **cannot tell** .... 2. ○ ○ ○ ○

3. $X = y + \frac{m}{s}$ If m were made smaller, what change would be made in the value of X?
(1) **remain the same** (2) **become larger** (3) **become smaller** (4) **cannot tell** .... 3. ○ ○ ○ ○

4. $X = y + m$ If y were to be made 1 larger, and m were to be made 1 smaller, what change would be made in the value of X?
(1) **remain the same** (2) **become larger** (3) **become smaller** (4) **cannot tell** .... 4. ○ ○ ○ ○

5. $X = y - \frac{1}{y}$ If the value of y were made larger, what change would be made in the value of X?
(1) **remain the same** (2) **become larger** (3) **become smaller** (4) **cannot tell** .... 5. ○ ○ ○ ○

6. $X = \frac{y}{m}$ Given that y and m are always equal. What change would be made in the value of X if y and m would be made larger in the same proportion?
(1) **remain the same** (2) **become larger** (3) **become smaller** (4) **cannot tell** .... 6. ○ ○ ○ ○

7. $X = y - m$ If m were made larger, what change would be produced in the value of X?
(1) **remain the same** (2) **become larger** (3) **become smaller** (4) **cannot tell** .... 7. ○ ○ ○ ○

8. $X = y + m - n$ If y, m, and n were all given the same value, what change would be produced in the value of X?
(1) **remain the same** (2) **become larger** (3) **become smaller** (4) **cannot tell** .... 8. ○ ○ ○ ○

9. $X = y + \frac{m}{s}$ If s were made smaller, what change would be made in the value of X?
(1) **remain the same** (2) **become larger** (3) **become smaller** (4) **cannot tell** .... 9. ○ ○ ○ ○

10. $X = y + m$ If m were made larger, what change would need to be made in the value of y so that X would not change in value?
(1) **remain the same** (2) **become larger** (3) **become smaller** (4) **cannot tell** .... 10. ○ ○ ○ ○

Score on Part 4 = Number right = ________

End of test; Close your paper.

APPENDIX B

COPY OF THE POSTTEST

The test copy included in this study is a copy of the questions and answers in the posttest. The posttest administered was the published copy of the _Lankton Algebra One Revised Edition_.

LANKTON FIRST-YEAR ALGEBRA TEST—FORM E

1 If $t = 2$, the value of $\frac{3t-4}{t}$ is

[a] 4
[b] 2
[c] 1
[d] −1
[DK]

2 In the area formula $A = d^2$, if A is 144, then d is

[e] 288
[f] 72
[g] 36
[h] 12
[DK]

3 If $\frac{1}{8}x = 12$, then x equals

[a] $\frac{2}{3}$
[b] $\frac{3}{2}$
[c] 96
[d] 20
[DK]

4 One of the factors of $36 - r^2$ is

[e] $2 - r$
[f] $3 - r$
[g] $4 + r$
[h] $6 + r$
[DK]

5 The length of a rectangle is 10 feet more than 3 times its width. If x represents the width of the rectangle, its length is

[a] $3(x + 10)$
[b] $3x + 10$
[c] $3x - 10$
[d] $x + 10$
[DK]

6 The average of a set of numbers is 6. The sum of the numbers is 144. How many numbers are in the set?

[e] 24
[f] 18
[g] 12
[h] 6
[DK]

7 From the equation $2x - 6 = 6$, the equivalent equation $2x = 12$ is obtained by

[a] multiplying both sides of the first equation by 2
[b] subtracting 6 from both sides of the first equation
[c] dividing both sides of the first equation by 2
[d] adding 6 to both sides of the first equation
[DK]

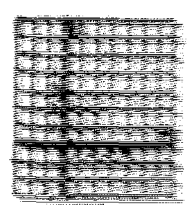
8 Which of the following equations has (5, 2) as a member of its solution set?

[e] $x - y = 3$
[f] $x - y = -3$
[g] $x + y = -3$
[h] $x + y = 3$
[DK]

9 The multiplicative inverse of 5 is

[a] −5
[b] $-\frac{1}{5}$
[c] $\frac{1}{5}$
[d] 1
[DK]

10 The graph below expresses the same relation as [illegible]



[e] [illegible]
[f] [illegible]
[g] [illegible]
[h] [illegible]
[DK]

11 [illegible]

[a] [illegible]
[b] [illegible]
[c] [illegible]
[d] [illegible]
[DK]

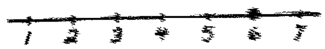
[illegible]

LANKTON FIRST-YEAR ALGEBRA TEST—FORM E

12 One of the factors of $a^2 - 8a + 16$ is

[**e**] $a - 8$
[**f**] $a - 4$
[**g**] $a + 2$
[**h**] $a + 4$
[DK]

13 Which graph represents the solution set of the equation $3n - n = 9$?

[**a**] 
[**b**] 
[**c**] 
[**d**] 
[DK]

14 The average of $+3, 0, -2, -7$, is

[**e**] -2
[**f**] $-\frac{3}{2}$
[**g**] 0
[**h**] 4
[DK]

15 If $m = -17$ and $n = -22$, how much greater is m than n?

[**a**] -17
[**b**] -5
[**c**] 5
[**d**] 39
[DK]

16 If $b \neq 0$, the expression $\frac{3a-b}{3b} - \frac{2a-b}{3b}$ equals

[**e**] $\frac{a}{3}$
[**f**] $\frac{a}{6b}$
[**g**] $\frac{a-2b}{3b}$
[**h**] $\frac{a}{3b}$
[DK]

17 If $2x + 5 = n$, then $2x$ is

[**a**] 5 less than n
[**b**] 5 more than n
[**c**] $\frac{1}{2}$ as large as n
[**d**] $\frac{1}{4}$ as large as n
[DK]

18 In the formula $H = 12 - 2b$, if b varies from 1 to 4, H varies from

[**e**] 1 to 4
[**f**] 10 to 20
[**g**] 10 to 8
[**h**] 10 to 4
[DK]

19 The absolute value of any number k is written

[**a**] $\sqrt{k}$
[**b**] $|k|$
[**c**] $-k$
[**d**] k
[DK]

20 If a is not an element of the set {0, 1}, then the quotient $\frac{a+1}{a} \div \frac{a-1}{a^2}$ equals

[**e**] $-a$
[**f**] a
[**g**] $\frac{a(a+1)}{a-1}$
[**h**] $\frac{a^2-1}{a}$
[DK]

21 The sentence, "x is a number at least as large as 75," may be written as

[**a**] $x = 75$
[**b**] $x \leq 75$
[**c**] $x > 75$
[**d**] $x \geq 75$
[DK]

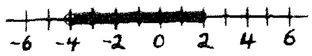
22 The inequality 2[illegible] is a true statement

[**e**] $n \geq 4$
[**f**] $n \leq 5$
[**g**] $n < 6$
[**h**] $n \geq 8$
[DK]

GO ON TO THE NEXT PAGE

LANKTON FIRST-YEAR ALGEBRA TEST—FORM E

23 The set of real numbers n represented in the graph below is equivalent to which of the following inequalities?



[**a**] $n > -4$

[**b**] $n \leq 2$

[**c**] $-4 < n < 2$

[**d**] $-4 < n \leq 2$

[DK]

24 A number is $\frac{1}{3}$ as large as another number and also 1 less than the other number. If n is the larger number, an equation by which n may be found is

[**e**] $3n = n + 1$

[**f**] $\frac{1}{3}n = n + 1$

[**g**] $\frac{1}{3}n = n - 1$

[**h**] $3n = n - 1$

[DK]

25 Which of the following is a *true* statement?

[**a**] $9 - 5 \geq 2$

[**b**] $7 + 7 < 14$

[**c**] $8 + 3 > 12$

[**d**] $10 - 7 \neq 3$

[DK]

26 If $\frac{x}{6} = \frac{3}{100}$, then x is

[**e**] .02

[**f**] .18

[**g**] .50

[**h**] .82

[DK]

27 If x is an element of the set $\{0, 1, 2\}$ and if $2y = x$, then y is an element of the set

[**a**] $\{0, 2, 4, 6, \ldots\}$

[**b**] $\{0, 1, 2\}$

[**c**] $\{0, \frac{1}{2}, 1\}$

[**d**] $\{0, \frac{1}{2}, 1, 1\frac{1}{2}, \ldots\}$

[DK]

28 The solution set of the equation $|x - 3| = 3$ is

[**e**] $\{0, 6\}$

[**f**] $\{0, 3\}$

[**g**] $\{3, 6\}$

[**h**] $\{-3, 3\}$

[DK]

29 The difference $5\pi r^2 - \pi r^2$ equals

[**a**] $4\pi r^2$

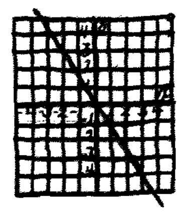
[**b**] 4π

[**c**] 4

[**d**] 5

[DK]

30 The graph below shows that each change in x of 1 unit corresponds to a change in y of



[**e**] 1 unit

[**f**] $1\frac{1}{2}$ units

[**g**] 2 units

[**h**] 3 units

[DK]

31 The inequality $x + 3 < 1$ is transformed to the equivalent inequality $x < -2$ by

[**a**] subtracting 3 from both sides of the first inequality

[**b**] adding -1 to both sides of the first inequality

[**c**] adding 3 to both sides of the first inequality

[**d**] subtracting 2 from both sides of the first inequality

[DK]

32 If $d \neq 0$ in the fraction $\frac{c}{d}$ and if d is multiplied by 2, the value of the fraction is always

[**e**] multiplied by 2

[**f**] divided by 2

[**g**] decreased by 2

[**h**] decreased by $\frac{1}{2}$

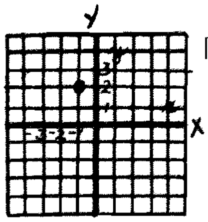
[DK]

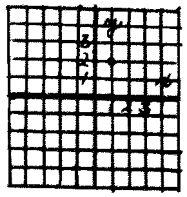
GO ON TO THE NEXT PAGE ►

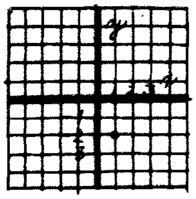
LANKTON FIRST-YEAR ALGEBRA TEST—FORM E

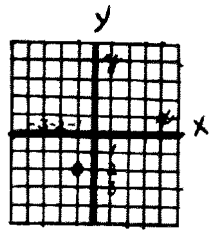
33 Which is the graph of the solution set of the two equations below?

$$2x - y = 4$$
$$x - 2y = 5$$

[a] 

[b] 

[c] 

[d] 

[DK]

34 The product $(x - 4)(\frac{x}{2} - 1)$ equals

[e] $\frac{x}{2} - 4$

[f] $x - x - 4$

[g] $\frac{x^2}{4} - 3x - 4$

[h] $\frac{x^2}{2} - x - 4$

[DK]

35 What is the solution set of the open sentence $7x + 3x = 10x$?

[a] {0, 1, 2}

[b] {0}

[c] {all numbers}

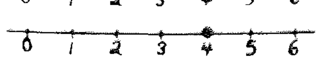
[d] {all integers}

[DK]

36 Which graph represents the solution set of the inequalities $3 < n < 5$?

[e] 

[f] 

[g] 

[h] 

[DK]

37 The expression $k + 2$ is a negative number for all values of k less than

[a] -2

[b] -1

[c] 0

[d] 2

[DK]

38 If p varies directly as s and $p = 8$ when $s = 4$, what is the value of p when $s = \frac{1}{2}$?

[e] 8

[f] 4

[g] 2

[h] 1

[DK]

39 The equation $(3 + x) - 4 = 3 + (x - 4)$ is an instance of a principle called

[a] reciprocal

[b] commutative

[c] associative

[d] distributive

[DK]

40 The solution set of $(x - 4)(1 - x) = 0$ is

[e] {4, −1}

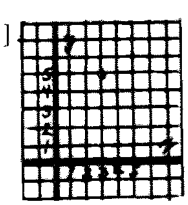
[f] {4, 1}

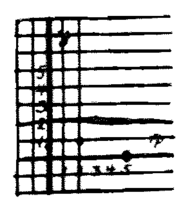
[g] {−4, −1}

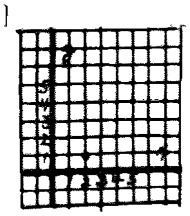
[h] {−4, 1}

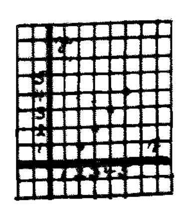
[DK]

41 The graph of the relation $y = \frac{5 - x}{3}$ in which both x and y are positive integers is

[a] 

[b] 

[c] 

[d] 

[DK]

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LANKTON FIRST-YEAR ALGEBRA TEST—FORM E

42 Which of the following is an instance of the distributive principle?

[**e**] $(x - y)(x + y) = (x - y)x + (x - y)y$

[**f**] $7 + x + 5 = 12 + x$

[**g**] $8 + x = x + 8$

[**h**] $(x + y)(x - y) = (x - y)(x + y)$

[DK]

43 The smallest integer greater than $-1\frac{1}{2}$ is

[**a**] -2

[**b**] -1

[**c**] $-\frac{1}{2}$

[**d**] 0

[DK]

44 In the formula $y = 50 - 10z$, the set of all the replacement numbers for z for which y is positive is

[**e**] {numbers greater than 5}

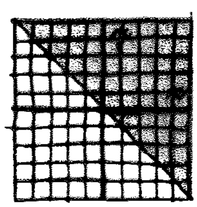
[**f**] {numbers greater than 0}

[**g**] {numbers less than 0}

[**h**] {numbers less than 5}

[DK]

45 The shaded portion of the graph below and its boundary line represent the open sentence



[**a**] $y > -x$

[**b**] $y \leq -x$

[**c**] $y \geq -x$

[**d**] $y < -x$

[DK]

46 The expression $\sqrt{20a^3}$ equals

[**e**] $4a^2\sqrt{5a}$

[**f**] $2a\sqrt{10a}$

[**g**] $2a\sqrt{5a}$

[**h**] $10a^2\sqrt{2a}$

[DK]

47 What is the solution set of the two equations below?

$$3x - y = 1$$
$$x - 3y = 1$$

[**a**] $\{(0, -1)\}$

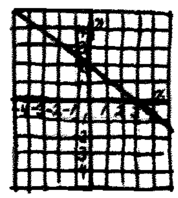
[**b**] $\{(0, -\frac{1}{3})\}$

[**c**] $\{(\frac{1}{2}, \frac{1}{2})\}$

[**d**] $\{(\frac{1}{4}, -\frac{1}{4})\}$

[DK]

48 The graph below shows that y is greater than 0 for all values of x which are



[**e**] greater than 0

[**f**] less than 3

[**g**] greater than 3

[**h**] less than 4

[DK]

49 The solution set of the open sentence $2 < z \leq 6$ where z is an integer is

[**a**] $\{3, 4, 5, 6\}$

[**b**] $\{3, 4, 5\}$

[**c**] $\{3, 4\}$

[**d**] $\{3\}$

[DK]

50 If $r \in \{4, 5\}$ and $s \in \{-1, 0\}$, the largest value the expression $3r - s$ may have is

[**e**] 12

[**f**] 13

[**g**] 15

[**h**] 16

[DK]

STOP! GO BACK AND CHECK YOUR WORK

APPENDIX C

A COPY OF A MIMEOGRAPHED DESCRIPTION OF PROGRAMED INSTRUCTION GIVEN TO ALL STUDENTS IN THE EXPERIMENTAL GROUP

What is programed instruction?

Programed instruction is not something new or different. The basic idea of programed instruction in the United States goes as far back as 1866. However, the concept of teaching with programed instructional materials was not widely held until the 1950's when B. F. Skinner, a Harvard University psychologist, clinically established the value of programed instruction. The use of programed instruction has grown to such an extent that by the early 1960's over 630 different courses were available by programed instruction.

"Programed instruction is simply a new, better way of writing a textbook,"[1] a textbook based on the latest principles of quality education. Under programed instruction every student is treated as an individual - an individual with a private tutor. The student is given information in small steps. Putting these steps together the individual builds from a limited source of information the concepts of the course. However, unlike using a conventional text, in a

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[1]William A. Deterline, An Introduction to Programed Instruction (Englewood Cliff, New Jersey: Prentice-Hall, Inc., 1962), p. 55.

programed text the student does not just read and build in his mind. Programed materials after every small amount of information require an active response from the student. The correctness of the response is immediately established by the textbook. The reason I say the correctness of the response, and not the error of the response, is that programed materials make every effort to eliminate errors and as such under many programs students should experience success over 90 per cent of the time.

Advantages of programed instruction.

1. Programed instruction allows for a breadth of understanding and not rote memorization as the main objective.

2. Programed instruction is capable of providing for a wider range of student ability than the normal classroom situation. Thus each student as an individual is able to proceed at his or her own speed.

3. Since each student takes the course as an individual rather than as a member of a class the student is not bogged down with group activities which are of little value to him. The result of this is a more efficient learning process, a process that may even reduce the amount of out-of-class homework for many students.

4. Since the teacher is not engaged in class presentations for one-half to three-fourths of every period he is

always available for individual or small group work. This can be either remedial work for a student having problems or enrichment topics for students having questions beyond the scope of the textbook.

Disadvantages of programed instruction.

The one major problem with programed instruction is that it puts a tremendous burden on the individual student. The student learns at his rate and it is difficult if not impossible for anyone else to determine this rate. Thus, the lazy, immature student may decide to go at a rate well below his level of ability and not cover the required material. Also, since a student works on his own, some students try to cheat the system and loaf for several periods at a time.

APPENDIX D

TABLE V

TEMAC ALGEBRA ONE GRADE STANDARDS

	Grade	Average	Chapters Finished
First nine weeks	1	95	7
	2	91	6
	3	84	5
	4	77	4
Second nine weeks	1	95	12
	2	90	11
	3	80	10
	4	70	8
Third nine weeks	1	95	19
	2	90	16
	3	80	13
	4	60	12
Fourth nine weeks	1	95	24
	2	87	21
	3	75	19
	4	60	17

Grade of 1 is an A, 2 is a B, 3 is a C, and 4 is a D.

These standards were used to determine the grades of all students taught by means of programed instruction using TEMAC. They are a listing of the minimum test averages and the minimum number of chapters covered by the end of the grading period. For example, in order for a student to receive a grade of 3 for the second nine weeks he must have covered at least ten chapters with an average test score of 80.

APPENDIX E

TABLE VI

RAW SCORES ON THE PRETEST AND POSTTEST

EXPERIMENTAL GROUP			CONTROL GROUP		
Student Number	Pretest Raw Score	Posttest Raw Score	Student Number	Pretest Raw Score	Posttest Raw Score
E 1	37	17	C 1	54	15
E 2	49	23	C 2	54	21
E 3	51	21	C 3	52	25
E 4	47	24	C 4	70	37
E 5	45	24	C 5	54	29
E 6	49	18	C 6	43	20
E 7	59	18	C 7	48	20
E 8	57	28	C 8	54	28
E 9	51	18	C 9	53	29
E 10	48	16	C 10	58	30
E 11	64	25	C 11	52	22
E 12	60	32	C 12	47	23
E 13	38	24	C 13	50	27
E 14	54	21	C 14	51	28
E 15	54	26	C 15	58	23
E 16	59	19	C 16	66	32
E 17	79	37	C 17	64	26
E 18	46	29	C 18	46	19
E 19	60	30	C 19	60	30
E 20	42	23	C 20	71	32
E 21	40	18	C 21	50	24
E 22	59	27	C 22	65	22
E 23	54	23	C 23	52	29
E 24	28	17	C 24	55	23
E 25	62	32	C 25	62	29
E 26	51	24	C 26	41	19
E 27	60	27	C 27	63	24
			C 28	45	28
Total	1403	647		1538	711
$\bar{X}$	51.96	23.96		54.93	25.39
s	10.07	5.66		7.73	4.81